1. Based on its position in the periodic table, how is the element with 16 protons **best** described?

A. brittle

B. ductile

C. good conductor of heat

D. semiconductor of electricity

2. Based on the periodic table, which set of elements forms ions with an oxidation number of –1?

A. lithium (Li), beryllium (Be), boron (B)

B. nitrogen (N), oxygen (O), fluorine (F)

C. fluorine (F), chlorine (Cl), bromine (Br)

D. lithium (Li), sodium (Na), potassium (K)

3. Which characteristics describe lithium (Li), magnesium (Mg), and gallium (Ga) based on their positions in the periodic table?

A. All three elements are shiny, conduct heat and electricity, react with water, and corrode in air.

B. All three elements are dull, do not conduct heat or electricity, do not react with water, and resist corrosion.

C. All three elements are brittle, melt at low temperatures, exist as a gas at room temperature, and form covalent bonds.

D. All three elements have a high ionization energy, show low reactivity with halogens, boil at high temperatures, and exist as liquids at room temperature.

4. An air bag for the driver's seat in a vehicle requires about 50 L of gas to fully inflate. A decomposition reaction produces gas to fill the air bag. Which decomposition reaction would produce the largest volume of gas for each mole of the initial solid?

A. $Mg_3N_2(s) \longrightarrow 3Mg(s) + N_2(g)$

B. $2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$

C. $CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$

D. $Na_2CO_3(s) \longrightarrow Na_2O(s) + CO_2(g)$

5. **Use the equation below to answer the question.**

Chemical Equation

	$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$		
molar mass (g/mol):	2.02	32.00	18.02

If 4.0 g of hydrogen gas (H_2) reacts with 36 g of oxygen gas (O_2), how many grams of water vapor (H_2O) will be produced?

A. 18g

B. 34g

C. 36g

D. 41g

6. Use the chart below to answer the question.

pH and Hydrogen Ion Concentration

pH	$[H^+]$
2.0	1×10^{-2}
6.0	1×10^{-6}
9.0	1×10^{-9}

Which statement **best** describes the relationship between pH and hydrogen ion concentration?

A. A base has a low pH and a lower $[H^+]$ than an acid.

B. An acid has a low pH and a lower $[H^+]$ than a base.

C. A base has a low pH and a greater $[H^+]$ than an acid.

D. An acid has a low pH and a greater $[H^+]$ than a base.

7. Use the chart below to answer the question.

Information About Three Atoms

Atom	Mass Number	Number of Protons
carbon (C)	12	6
nitrogen (N)	14	7
X	14	6

Which statement correctly identifies the atom labeled X?

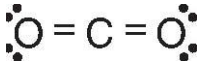
A. Atom X is an ion of N, because it has the same mass number as N and one less proton than N.

B. Atom X is an isotope of N, because it has the same mass number as N and one less proton than N.

C. Atom X is an ion of C, because it has the same number of protons as C and two more neutrons than C.

D. Atom X is an isotope of C, because it has the same number of protons as C and two more neutrons than C.

8. Use the structural formula below to answer the question.



Which statement is **best** supported by the structure of the molecule?

A. It is metallic because carbon is classified as having the character of a metal.

B. It is nonpolar covalent because the oxygen and carbon atoms are sharing electrons.

C. It is polar covalent because electrons flow from the oxygen atoms to the carbon atom.

D. It is ionic because strong double bonds occur between the oxygen atoms and the carbon atom.

9. Which action demonstrates colligative properties?

A. adding ice to a drink to lower its temperature

B. adding heat to a reaction to increase the reaction rate

C. adding acid to electrochemical cells to allow batteries to produce a higher voltage

D. adding antifreeze to radiators to allow cars to operate over wide-ranging temperatures

10. Use the data table below to answer the question.

Temperature Data

Temperature of Water Before Adding NaOH	Temperature of Water After Adding NaOH
20°C	40°C

A sample of NaOH is mixed with water. The collected data are shown in the table. Which statement is supported by the data?

A. The reaction is exothermic because heat is given off to the surroundings.

B. The reaction is endothermic because heat is given off to the surroundings.

C. The reaction is exothermic because heat is absorbed from the surroundings.

D. The reaction is endothermic because heat is absorbed from the surroundings.

11. Which statement **best** explains why a catalyst speeds up the rate of a chemical reaction?

A. The catalyst reduces the activation energy.

B. The catalyst increases the energy of the reactants.

C. The catalyst increases the surface area of the reactants.

D. The catalyst reduces the number of molecular collisions.

12. The kinetic molecular theory assumes that all gases behave ideally. How do oxygen molecules **most likely** differ from acting like an ideal gas at extremely low temperatures?

A. by having zero volume

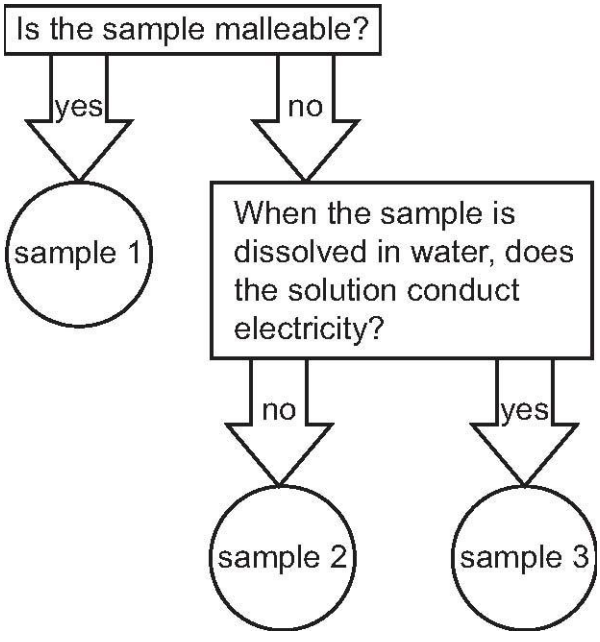
B. by slowing their movement

C. by condensing into a liquid

D. by colliding with other molecules

13. Use the chart below to answer the question.

Classification Chart for Chemical Bonding



A student developed this classification chart to study the types of chemical bonding in three samples. The student tested each sample according to the criteria in the chart. Which conclusion is **best** supported by the information in the chart?

A. Sample 1 contains ionic bonds because it is malleable.

B. Sample 2 contains metallic bonds because it is not malleable.

C. Sample 2 contains covalent bonds because the solution does not conduct electricity.

D. Sample 3 contains covalent bonds because the solution conducts electricity.

14. According to the kinetic molecular theory, how are ideal gas particles different from actual molecules of oxygen gas (O_2)?

A. Ideal gas particles lose energy when they collide, while O_2 molecules collide elastically.

B. Ideal gas particles have a zero volume, while O_2 molecules have a measurable volume.

C. Ideal gas particles are close together, while the distance between O_2 molecules is large.

D. Ideal gas particles attract each other, while O_2 molecules have no intermolecular forces.

15. Use the chemical equation below to answer the question.

Chemical Equation

$HCl(g) + NH_3(g) \longrightarrow NH_4Cl(s)$

Why does this equation represent a Brønsted-Lowry acid-base reaction but not an Arrhenius acid-base reaction?

A. Hydrogen chloride transfers a chloride ion to ammonia.

B. Hydrogen chloride transfers a hydrogen ion to ammonia.

C. Ammonia receives a hydroxide ion but does not produce hydrogen ions.

D. Ammonia receives a hydrogen ion but does not produce hydroxide ions.

16. The molar mass of oxygen gas (O_2) is approximately 32.00 g/mol. What is the volume of 28.0 grams of oxygen gas (O_2) at standard temperature and pressure (STP)?

A. 19.6 L

B. 21.2 L

C. 25.6 L

D. 39.2 L

17. What is the molarity of a 250.0 mL aqueous solution containing 50.0 grams of NaCl (molar mass = 58.44 g/mol)?

A. 3.42 M

B. 4.28 M

C. 20.0 M

D. 25.0 M

18. Use the list below to answer the question.

Boiling Points of Some Alcohols

- methanol (CH_3OH), 65°C
- ethanol (C_2H_5OH), 78°C
- *n*-propanol (C_3H_7OH), 97°C
- *n*-butanol (C_4H_9OH), 118°C

A lab group measured the boiling points of some alcohols and presented their data in the list shown. Which conclusion can the lab group make about the intermolecular forces within each alcohol?

A. The strength of the covalent bonds increases with the number of carbon atoms.

B. The amount of dipole-dipole interaction increases with the total number of atoms.

C. The strength of London dispersion forces increases with the total number of atoms.

D. The amount of hydrogen bonding increases greatly with the number of carbon atoms.

19. Which statement identifies a characteristic of an ideal gas particle?

A. It moves only in straight lines.

B. It occupies a significant volume.

C. It loses energy during a collision.

D. It experiences molecular attraction.

20. Which formula represents a compound that acts as a Brønsted-Lowry base in water?

A. HCl

B. NH_3

C. NaCl

D. $C_6H_{12}O_6$

21. Use the equation below to answer the question.

Chemical Equation

	$Fe(s) + CuCl_2(aq) \longrightarrow FeCl_2(aq) + Cu(s)$			
molar mass (g/mol):	55.85	134.45	126.75	63.55

An iron (Fe) nail with a mass of 2.1 g is placed into a beaker containing an excess amount of a 0.20 M copper(II) chloride ($CuCl_2$) solution. After 20 minutes, the nail is removed from the solution, and the newly formed copper product has a mass of 1.5 g. Based on the initial amount of iron available, what is the theoretical yield of copper, and why is the actual yield different?

A. The theoretical yield is 1.8 g. The actual yield is smaller because the reaction did not go to completion.

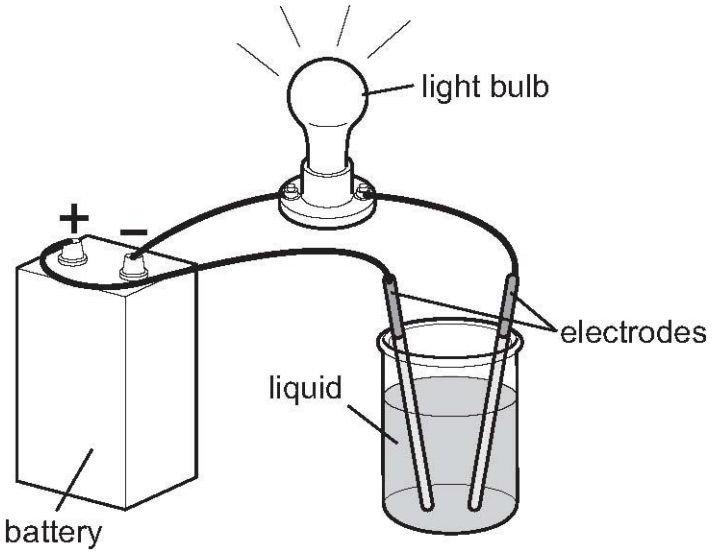
B. The theoretical yield is 2.4 g. The actual yield is smaller because the reaction did not go to completion.

C. The theoretical yield is 1.8 g. The actual yield is smaller because the concentration of $CuCl_2$ was higher than 0.20 M.

D. The theoretical yield is 2.4 g. The actual yield is smaller because the concentration of $CuCl_2$ was higher than 0.20 M.

22. Use the setup below to answer the question.

Conductivity Investigation Setup



An unknown liquid is shown in the beaker. Electrodes were placed in the beaker, causing the light bulb to glow. What is the **most likely** conclusion about the liquid?

A. It is a colloid that transfers energy.

B. It is a mixture that contains a covalent compound.

C. It is a pure substance that allows the free flow of electrons.

D. It is a solution that contains a salt which dissociates in water.

23. Use the data table and equation below to answer the question.

Hydrogen Gas Sample

	Pressure (atm)	**Volume (mL)**
initial	1.05	15.1
final	0.82	?

Boyle's Law

$P_1V_1 = P_2V_2$

A sample containing hydrogen gas (H_2) is sealed in a container that is able to vary in size as the pressure changes. Given the measured data, what is the final volume of the gas, using the correct number of significant digits?

A. 19mL

B. 19.3 mL

C. 19.34 mL

D. 20mL

24. Use the equation below to answer the question.

Specific Heat Formula

$$Q = mc_p\Delta T$$

A student used a calorimeter to find the specific heat of water. The student found that 16,870 joules of energy raised the temperature of 200.0 grams of water from 19.5°C to 38.3°C. Using the formula shown, what is the experimental value for the specific heat of water?

A. 2.92 J/(g •°C)

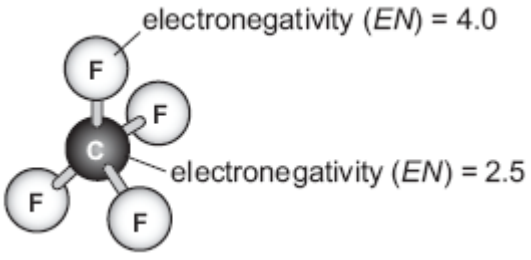
B. 4.18 J/(g •°C)

C. 4.33 J/(g •°C)

D. 4.49 J/(g •°C)

25. Use the information below to answer the question.

Carbon Tetrafluoride (CF_4) Molecule



Electronegativity of Bond Types

Bond	Difference in Electronegativity
nonpolar	< 0.5
polar	0.5–1.7
ionic	> 1.7

A student tests the polarity of different molecules by checking for water solubility and using the rule “like dissolves like.” Based on the rule, polar water molecules should dissolve other polar molecules, but not molecules that are nonpolar. Which conclusion can the student correctly make about CF_4 based on the diagram?

A. Carbon tetrafluoride has polar covalent bonds with all the dipoles adding together to make the molecule polar and soluble in water.

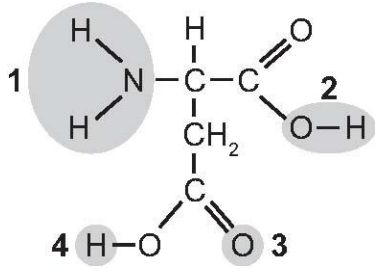
B. Carbon tetrafluoride has nonpolar covalent bonds with all the dipoles adding together to make the molecule polar and soluble in water.

C. Carbon tetrafluoride has polar covalent bonds, and the dipoles all cancel, making the molecule nonpolar and nearly insoluble in water.

D. Carbon tetrafluoride has nonpolar covalent bonds and no net dipole, making the molecule nonpolar and nearly insoluble in water.

26. Use the structure below to answer the question.

Aspartic Acid Molecule



Which part of the molecule is released, causing aspartic acid to act as a Brønsted-Lowry acid?

A. part 1

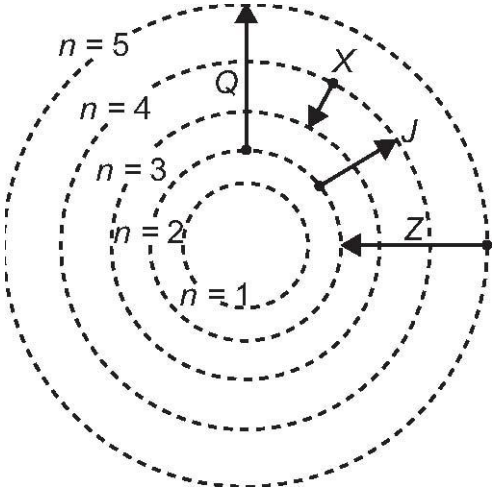
B. part 2

C. part 3

D. part 4

27. Use the diagram below to answer the question.

Electron Transitions for Hydrogen Atoms



The electron transitions shown in the diagram all involve visible light. Which electron transition will cause light to be emitted resulting in a high-energy violet line in the emission spectrum of hydrogen?

A. *Q*

B. *X*

C. *J*

D. *Z*

28. Use the data table below to answer the question.

Magnesium Investigation Data

Trial	Mass of Crucible (g)	Mass of Crucible and Mg Before Heating (g)	Mass of Crucible and Mg After Heating (g)
1	7.11	8.24	8.92
2	7.09	11.14	13.84
3	7.13	14.44	19.19

A student heated magnesium (Mg) in a crucible in the presence of oxygen until light and heat were emitted. The mass of the crucible and Mg were recorded before and after heating. Which conclusion is **best** supported by the recorded data?

A. Heating Mg caused a gas to form.

B. Heating Mg destroyed some of the matter.

C. Heating Mg increased the size of its particles.

D. Heating Mg resulted in the formation of a new compound.

29. Rust forms when iron reacts with oxygen gas to form iron(III) oxide. Which balanced chemical equation correctly represents the formation of rust?

A. $Fe + O \rightarrow FeO$

B. $2Fe + 3O \rightarrow Fe_2O_3$

C. $3Fe + O_2 \rightarrow Fe_3O_2$

D. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

30. A student is asked to determine the concentration of a sample of hydrochloric acid (HCl) during a titration lab. Which tools would **best** help the student safely collect data during this titration lab?

A. burette, beaker

B. pipette, beaker

C. burette, Erlenmeyer flask

D. pipette, Erlenmeyer flask

Summary

Sequence	Key	Set	Objective
1	A	IASEOC	C.1.1.1
2	C	IASEOC	C.1.1.1
3	A	IASEOC	C.1.1.1
4	B	IASEOC	C.1.3.5
5	C	IASEOC	C.1.3.5
6	D	IASEOC	C.1.3.8
7	D	IASEOC	C.2.4.2
8	B	IASEOC	C.2.1.1
9	D	IASEOC	C.1.3.7
10	A	IASEOC	C.2.3.3
11	A	IASEOC	C.2.5.3
12	C	IASEOC	C.1.2.3
13	C	IASEOC	C.2.1.3
14	B	IASEOC	C.1.2.3
15	D	IASEOC	C.1.2.4
16	A	IASEOC	C.1.3.4
17	A	IASEOC	C.1.3.6
18	C	IASEOC	C.2.1.3
19	A	IASEOC	C.1.2.3
20	B	IASEOC	C.1.2.4
21	B	IASEOC	C.1.3.5
22	D	IASEOC	C.2.1.6
23	A	IASEOC	C.1.3.3
24	D	IASEOC	C.2.3.1
25	C	IASEOC	C.2.1.3
26	D	IASEOC	C.1.2.4
27	D	IASEOC	C.2.4.3
28	D	IASEOC	C.1.6.1
29	D	IASEOC	C.2.5.2
30	C	IASEOC	C.1.6.2